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5.3.2 Solar Water Heating

Heating water using the sun's energy is practical in almost any climate. Although solar systems can meet the total hot water demand in many regions of the United States during summer months, supplemental water heating is often required in winter.

Opportunities

Many people assume that solar water heating is an option only in extremely sunny or warm climates. That is not the case. In fact, a solar water heating system might be more cost-effective in New Hampshire than in Arizona—depending on the cost of the energy being replaced. Solar water heating is easiest to justify economically when it is replacing electric water heating and when hot water demand is both high enough to justify the initial equipment investment and fairly constant throughout the week. Good candidates are laundries, hospitals, dormitories, gymnasiums, and prisons. Swimming pools are good warm-season applications—very simple, low-cost systems work very well. While costs will be lowest when solar water heating is installed during initial construction, retrofits onto existing buildings are relatively easy and can generally be done with little disturbance to building occupants.

Technical Information

Solar thermal water heating systems come in various configurations suited for different climate zones and applications. The two basic components are collectors, usually mounted on the roof or ground, and an insulated storage tank. Active systems contain mechanical pumps for circulating the collection fluid, which is either plain water or water containing propylene glycol (nontoxic) antifreeze. Passive systems do not have pumps. The most common configurations of solar water heaters are as follows:

Passive thermosiphoning systems rely on the buoyancy of warm water rising from the collector to the tank, which is always located above the collector. Heat pipes—sealed tubing systems containing refrigerant—can also be used for heat transfer from panel to tank.

Passive integral collector-storage (ICS) systems combine collection and storage. Most common are a series of large-diameter (4-inch/100 mm) copper tubes located within an insulated box with glass cover plate. ICS systems are generally plumbed in-line with the building's tap water, so they are pressurized. Potable water enters at the bottom of the ICS collector, and warm water is drawn from the top. With ICS systems, roof structures must be strong enough to support the weight of water-filled collector tanks.

Active direct or "open-loop" systems are simple, very efficient, and suitable for mild and moderate climates with good water quality. In direct systems, potable water is pumped through the collector. Often, photovoltaic- (PV-)powered, DC pumps are used, providing a built-in control system—when it is sunny, water is circulated through the collector. Damage to collectors is a concern if water is hard or corrosive. Also, freeze protection is needed. Direct systems are especially applicable to swimming pool heating.

Active indirect or "closed-loop" systems are dependable and suitable for all climates. Indirect systems circulate nontoxic antifreeze (propylene glycol) through the closed loop, which consists of collector, piping, and heat exchanger located at the storage tank. Nontoxic antifreeze in the collector and exposed piping ensures protection from freeze damage, corrosion, and scaling. Like direct systems, indirect systems may use PV-powered pumps; otherwise, differential thermostats are typically used to turn AC pumps on and off.

FREEZE PROTECTION

Freeze protection is an important consideration in all but tropical climates. Four primary strategies are used with active solar water heating:

- **Drainback systems** include a small reservoir into which water is drained from collectors and exposed piping whenever the circulating pump is turned off. This provides reliable freeze protection even when electrical power fails. It also protects the fluid from high temperatures by turning off the pump and draining the collector.
- **Draindown systems** dump water from a collector into a drain when triggered by near-freezing temperatures. They may also be manually drained in case of power failure during freezing. Draindown systems historically have been the least reliable because valves may freeze closed or become clogged with corrosion, preventing drainage.
- **Recirculation systems** utilize warm water from the storage tank to circulate into the collectors during freezing weather. They should be considered only in very mild climates.
- **Indirect systems** are filled with a nontoxic antifreeze solution all the time. They are reliable for use in any climate and are very effective at avoiding freeze damage, though if the pump fails or electricity is lost, the antifreeze may be damaged in the stagnating collector. A heat exchanger is required to heat the potable water.

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Photo: Warren Gretz

Solar water heating directly substitutes renewable energy for conventional fossil fuels or electricity. This array of parabolic trough collectors at a prison was paid for through a FEMP Energy Savings Performance Contract or ESPC.

SOLAR COLLECTORS

Three basic types of collectors are used for active solar water heating:

- **Flat-plate collectors** are the most common and generally consist of insulated rectangular frames containing small-diameter, fluid-filled copper tubes mounted on copper or aluminum absorber plates. Selective-surface coatings are applied to the tubing and absorber plates to emit less heat radiation. High-transmission tempered glass covers the absorber.
- **Evacuated-tube collectors** utilize a tube-within-a-tube design similar to a thermos bottle. A vacuum between the fluid-filled inner copper tube (generally with absorber fin) and glass outer tube permits maximum heat gain, minimum heat loss, and very high temperatures.
- **Parabolic trough collectors** focus sunlight onto a tube with selective-surface coating (usually contained within a vacuum tube). These systems tend to be more complex than stationary collectors because they have to track the sun as it moves across the sky, but performance is very good. They are most appropriate for large commercial installations requiring significant quantities of hot water. In addition to providing hot water, they can be used for process heat and absorption cooling. The recent development and commercialization of compound parabolic collectors promises significant improvements in performance. Because the collectors focus sunlight, they are a poor choice for cloudy climates.

Solar systems should be tested and certified by independent groups such as the Solar Rating and Certification Corporation (SRCC) or the Florida Solar Energy Center (FSEC).

Colder climate zones require more collector area and indirect systems with superior freeze-protection capabilities.

Removing trees to provide access to sunlight for solar collectors could be a net energy loser if there is substantially more heat gain through exposed windows and thus increased cooling loads. Site collectors carefully, and prune trees selectively.

At times of the year when collectors harvest sunlight very efficiently, water temperatures may be above 140°F (60°C). Ensure that mixing valves are installed to keep users from being scalded.

On direct systems, collectors may require periodic treatment with a nontoxic solution, such as diluted vinegar, to remove scaling buildup that inhibits heat transfer and efficiency.

$ The economics of installing solar water heating depend on the cost of the fuels being replaced. Hot water demand, patterns of usage, incoming water temperature, and availability of solar energy are also key considerations. Retrofitting solar water heating into existing buildings is complicated by the need to provide access for running pipes and space in mechanical rooms for larger storage tanks. Solar water heaters typically provide 40–80% of annual hot water needs.

References

"Solar Water Heating," *Federal Technology Alert,* Federal Energy Management Program, Department of Energy, Washington, DC, September 1995 (also available on the Web at www.eren.doe.gov/femp/).

Contacts

The FEMP Help Desk at (800) DOE-EREC (363-3732) or at www.eren.doe.gov/femp/ can provide technical assistance and information about financing via ESPCs.

Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922; 407/638-1000; www.fsec.ucf.edu (Solar Rating and Certification Corporation—same address; 407/638-1537; www.solar-rating.org).

Center for Buildings and Thermal Systems, National Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401; 303/275-3000; www.nrel.gov/buildings_thermal/.